

are met with in almost every extensive practice, are briefly noticed in the thirty-first chapter. He does not, however, attempt to explain at any length their pathology. He merely says that almost every possible morbid condition of the brain may cause aphasia, if the routes and centres for speech are either directly injured or if their functions are indirectly and temporarily disordered from pressure, ischæmia or collateral hyperæmia, or perhaps from reflex irritation and irradiation. One remark of the author's in this connection' appears to us to require explanation. He says that in cases of functional or hysterical aphasia, the words are intact, as is likewise the connection between the words and ideas, but that the interruption is somewhere between the word centre and the muscular apparatus of speech, that the general cortical and infra-cortical excitation, by means of which the conception is translated into words, is too weak, and that the so-called "moral treatment" is efficacious in some of these cases by supplying or reinforcing this psychic excitation. This is, it appears to us, rather too general a statement, without more qualifications than it here receives, we have met with cases of what might well be called transient hysterical aphasia, occurring from uterine irritation in neurotic females, in which the disorder seemed to affect higher cerebral centres than are here admitted.

We are compelled to pass the remaining portions of this work, those in which are described the various dysphasic or dyslogic disorders of speech, and its mechanical derangements from lesions or deficiencies of the more peripheral organs concerned in its production with only bare mention. We can honestly refer the reader to this volume, as the most thorough and complete monograph of the subject that has as yet appeared. While the tendency of the author to amplify on certain points, may possibly be criticised, it must be admitted that this could hardly be avoided, and that there is a certain advantage in having these subjects viewed from their physiological side, by so eminent an authority as Prof. Kussmaul. And, as we have said before, these parts materially add to the completeness of the work.

II.—THE FUNCTIONS OF THE BRAIN.

THE FUNCTIONS OF THE BRAIN. By DAVID FERRIER, M. D.
With Numerous Illustrations; P. 323. G. P. Putnam's
Sons, New York.

(CONTINUED FROM THE JANUARY NO.)

After a consideration of the functions of the semi-circular canals, and the maintenance of equilibrium, Dr. Ferrier passes to a study of the functions of the optic lobes.

He says that the facts of anatomical, and of physiological research, mutually support the view that the *corpora quadrigemina*, though not the centres of vision proper, are centres of co-ordination of retinal impressions with special motor reactions.

Before proceeding to relate the results of his own experiments, he gives a short review of the anatomical and physiological researches of Gratiolet, Meynert, Broadbent, and others. Dr. Ferrier describes the results of a long series of experiments conducted upon various animals, and more especially upon monkeys, in relation to the functions of these bodies. He says, in respect to the latter class of animals, the results of a lesion of both optic lobes were that the animal was rendered completely blind; a fact which, among other tests, was ascertained some twelve hours after the operation, by reason of its inability to discern the position of some milk which it was eager to reach, and which it drank eagerly when the dish was held to its mouth. The pupils were dilated. "For some hours the animal kept its eyes closed, or only opened them partially when aroused, but there was no real ptosis. Before death the eyes could be opened freely. With the exception of sight, the other senses were retained." Movements of the limbs were still made, and the animal could grasp firmly, as before, both with hands and feet.

"To sum up the results of destructive lesions of the optic lobes, in the various animals experimented on, we have blindness, paralysis of irido-motor, and some oculo-motor reactions; disorders of equilibrium and locomotion in frogs, and apparently in other animals, annihilation of certain forms of emotional expression.

"Simple irritation of one optic lobe caused the opposite pupil to become widely dilated, followed almost immediately by dilatation of the pupil of the same side. The eyes are widely opened, and the eye-brows elevated; the eye-balls are directed upward, and the opposite to that of the optic lobe which is irritated. The head is moved in the direction of the eyes; the ears are strongly retracted; the arms are approximated to the sides, and drawn back flexed at the elbows; and ultimately, when the stimulation is kept up, a state of complete opisthotonus is produced. Irritation of the testes or posterior tubercles produces the same effects, and in addition, cries are excited varying in character from a short bark, caused by the slightest contact of the electrodes, to all varieties of vocalization, when the stimulation is continued,

"The motor effects are shown, first on the opposite side of the body, but ultimately both sides become affected by unilateral irritation."

Dogs and cats, the jackal, rabbits, pigs, and other animals are affected in a similar manner, as far as could be expected in view of their differences of organization.

The functions of these bodies appear to us to be so important

that we will give considerable space to the statements of the views of Dr. Ferrier, and all the more so, because of the relation which they sustain to those diseases of which tetanus may be taken as the type.

"The destruction of the corpora quadrigemina annihilates the manifestation of those functions which still remain practically unimpaired by removal of the cerebral hemispheres, that is, equilibration, locomotion, and in some measure, emotional expression. We have, therefore, reason to believe that the *corpora quadrigemina* form an essential part of the central mechanism by which these are rendered possible, and there is an evident relation between the development of the ganglia, and the degree of independence with which some of these functions are manifested after removal of the hemispheres.

"The corpora quadrigemina as compared with the cerebral hemispheres are relatively large, and in these animals particularly, we find that removal of the hemispheres has less effect on equilibrium and co-ordinate locomotion than in animals with more highly developed hemispheres.

"The apparent retention of the power of forward progression in frogs, after the removal of the optic lobe, seems to me, more of the character of mere change in position, caused by sudden reflex movements, consequent on powerful reflex stimulation; for, in several experiments which I have made, I have found that when the optic lobes have been thoroughly removed, the animals cease to make true co-ordinate attempts at progression, and are unable to maintain their ordinary attitude."

Dr. Ferrier declines any attempt to differentiate between the optic ganglia, as such, and the underlying tracts of the nervous system, for he says: "I do not think it possible to determine experimentally, what are the functions of the mesencephalic ganglia and cerebellum, apart from their connections and relations to the crura and pons."

Says Dr. Ferrier: "Momentary irritation of the optic lobes, excites a reaction closely resembling the sudden backward start, which we see reflexly excited by the sudden approximation of an external object to the eyes. In this we have optical impressions co-ordinated with muscular actions, a result of which is to withdraw the head and eyes from dangerous approach." "The contraction of the facial muscles, together with the general *opisthotonus* which results from powerful stimulation of the *corpora quadrigemina* in mammals, may be regarded as a physical manifestation of painful stimulation in general. The phenomena are of the same character as those which are induced by the sensory irritation through the spinal centres, such as are observed in idiopathic or traumatic tetanus.

"The clenching of the teeth, with retraction of the angles of the mouth, which is such a common manifestation of painful stimulation of sensory nerves, may be accounted for by the structural connection of one of the sensory roots of the fifth

nerve with the *corpora quadrigemina*. The dilatation of the pupils, which is so readily induced by irritation of the *corpora quadrigemina*, is probably of the same nature, that is, an indication or expression of sensory irritation.

"It is well known that sudden, or painful stimulation of sensory nerves is associated with dilatation of the pupils; this reaction is produced through the medium of the sympathetic nerves, which act on the dilated fibres of the iris, for it has been found by Knoll, [Eckhardt's Beitræge,] that irritation of the *corpora quadrigemina* causes no dilatation when the cervical sympathetics have been divided.

"These results are in accordance with the theory of the co-ordination in the *corpora quadrigemina*, of sensory impressions with the mechanism of emotional expression." (P. 82.)

In short, the various considerations had by Dr. Ferrier, have led him to declare "that the relation between the phenomena of irritation, and destruction of the *corpora quadrigemina*, though in many respects one of a hypothetical nature,—tends to support the view that these ganglia are the centres especially concerned in the reflex expression of feeling or emotion." "This is rendered still more probable by the recently demonstrated influence which the *corpora quadrigemina*, or more properly, the deeper parts of the *corpora quadrigemina* exert on the functions of circulation, modifications of which are one of the most frequent concomitants of states of feeling or emotion. (P. 83.)

"In addition to these facts, it has been stated by *Valentin* and *Budge*, that irritation of the *corpora quadrigemina* has a direct influence on the viscera, causing contractions of the stomach, intestines and bladder. These, effects, if well established, would be another proof of the relation of the *corpora quadrigemina* to the reflex manifestations of emotion, for it is well known that under certain forms of emotion, contractions of the stomach and bladder may occur, as shown by the sudden expulsion of their contents. Monkeys in particular, express terror in this manner." From all of which it would appear, as a result of Dr. Ferrier's experiments, that the *corpora quadrigemina*, whatever other functions they may perform, are concerned in the reflex expression of emotion and especially of the emotions which appear to result from visual sensations, whether as regards acts of expression or those having relation to the maintenance of equilibrium.

We would be glad to give more space to the consideration of this subject than we can in the present notice. It is one worthy of serious study, on account of its widespread and important relations, both physiological and pathological. We dismiss it, at the present, with the hope of returning to it at some time in the future.

Dr. Ferrier next begins the study of the functions of the cerebellum, a subject which, as is well known, to those who attend to the progress of knowledge in regard to the nervous

system, embraces certain of the most unsettled and closely disputed questions within the domain of physiology. The most competent among physiologists have adopted widely different views.

The cerebellum forms an apparatus, as it were, lying off to one side of the great central axis of the nervous system. It reaches out and establishes connections with the summit of the cerebro-spinal axis, by means of bands of fibres, as is well known. These bands are three in number, the superior, the middle, and the inferior.

By means of the first, the connection is made between the cerebellum and the cerebral hemisphere of the side opposite; by the middle peduncle the connection is had with the pons, and the groups of nerve cells that lie imbedded between its fibres; while by means of the inferior peduncle a connection is had with the gray matter of the spinal cord, probably with its anterior and posterior columns, or the spinal apparatus for the co-ordination of muscular movements.

But, there is comparatively a great unanimity of opinion among physiologists in respect to the view, that the cerebellum is one of the chief organs concerned in the maintenance of equilibrium in muscular action. This position, however, has been strongly contested, both on the grounds of experiment, and pathological observation.

Cases have been cited from both these sources, which have seemed to require this view to be either modified or abandoned. These are discussed at some little length by Dr. Ferrier, and especially the remarkable case cited by Combette, that of a girl in which there was found to be complete absence of the cerebellum, and yet she had been able to walk, and did not present those symptoms which we might naturally expect, if the cerebellum is charged solely with this function.

The remarks of M. Vulpian are quoted, touching still another case, in which the cerebellum was destroyed by disease, but in which the power of co-ordination of movements was retained, only the patient was observed to totter when he walked.

M. Vulpian says: "There we have a case in which the cerebellum was destroyed, and yet the patient could walk, though in an unsteady manner, but if this (Flourens's) hypothesis, were well founded he ought not to have been able to stand or walk, and especially if the combination of muscular contraction necessary, for locomotion, or maintaining the erect attitude, ought to have been altogether impossible."

Dr. Ferrier continues at some length the discussion of cases like those just cited, without reaching any very satisfactory conclusions, and then passes on to relate the results of his excitation and mutilation experiments. He reports a large number of highly suggestive observations, but which we do not have space to consider in detail. But in general, electrical excitation of different parts of the cerebellum of monkeys was found to

cause movements of the eyes in various directions, the excitation of the same parts, generally being followed by the same movements. Besides the ocular motions, "certain movements of the head and limbs were likewise produced." As regards the movement of the limbs they occurred on the same side, as that to which the half of cerebellum belonged, to which the exciting agent was applied. It will be noticed that excitation of the cerebellum led to different results from that of excitation of the cerebral hemispheres, for in the latter case, at least, according to Dr. Ferrier, the movements are generally in the opposite half of the body. This agrees perfectly with the results of a study of the mutual anatomical relations of the cerebellar and cerebral hemispheres, whether healthy or morbid. Irritation of the cerebellum is followed by contraction of the pupils, especially that of the eye of the same side; viz., the side corresponding to the half of the cerebellum operated on, and the contraction was found to be more or less permanent. No vomiting or sign of excitation of the genital organs, was observed in any of the animals operated on, though special attention was directed to these points.

Dr. Ferrier makes certain remarks *apropos* to excitation experiments on the cerebellum, which have been suggested by his exceptionally large experience with the higher animals, more especially monkeys, and which it appears to us should be remembered, in endeavoring to estimate the value of single experiments, or even short series of the same. They are as follows: "It is to be noted in reference to electrical imitation of the cerebellum, that occasionally stimulation is absolutely without effect at first, and that after a lapse of sometime, the phenomena follow with great precision. I have not been able to satisfy myself with respect to these variations, as to whether they depend on degrees of anesthesia, or states of shock, or not. From another cause, the excitability of the cerebellum is subject to variations, which render the investigation troublesome, and, unless sufficient care is taken, may easily lead to apparently contradictory results.

"Frequently, after the application of the electrodes, a condition of nystagmus comes on, and lasts for sometime, so that unless due time is allowed for the subsidence of this irritation, the results of applying the electrodes to another part become so confused with the effects of the preceding, that analysis is impossible. The results above described are those which I have obtained after careful repetition on different animals, and with due regard to those precautions which I have indicated as being necessary." (P. 101.)

Essentially the same results were obtained by operating on the cat, dog and rabbit.

The relations which Dr. Ferrier would seem to have shown to exist between the state of the cerebellum and motion of the eyes, and disturbances of equilibrium, throw some light on, and in return receive some confirmation from, "certain phenomena

frequently observable in connection with disease or injury of the cerebellum." Dr. Ferrier also called up, in confirmation of his experimental results, "the phenomena which are observed in a man when a galvanic current is passed transversely through the skull in the cerebellar region, and which were first described, according to Dr. Ferrier, by Purkinje. (1827.)

These phenomena have been studied by Hitzig in his work on the brain, and which was reviewed at some length in this JOURNAL. (Vol. 1, p. 513, 520.)

They are described as follows by Dr. Ferrier: "When a galvanic current of moderate intensity is passed through the head by placing the poles of a battery in the mastoid fossæ just behind the ears, the individual experiences a feeling of vertigo, in which the relation of his body to surrounding objects seems to be, or is, actually disturbed, or external objects seem to alter their relation to him. The direction in which the equilibrium is disturbed, or in which objects seem to move, depends on the direction of the current through the head. When the positive pole, or anode, is placed on the right mastoid fossa, and the negative pole, or cathode, on the left, so that the current passes from right to left, at the moment when the circuit is closed, the head and body suddenly sink toward the anode, while external objects seem to wheel to the left. . . . When the eyes are closed, the appearance of motion is transferred to the individual himself, who feels as if he were whirled from right to left, or as if the basis of support on the left side had been suddenly withdrawn. The direction is exactly reversed when the positive pole is placed on the left, and the negative on the right side, or, while the electrodes maintain their former position when the circuit is broken." (P. 106.)

The eyeballs are moved, according to Hitzig, in the same direction as the head, and frequently are thrown into oscillations or nystagmus, that is, the movement is towards the anode. This motion is the same as that which results from irritation of the corresponding side of the cerebellum. It is the anode, (positive pole) therefore which excites the cerebellum. This was found to be a general fact by Hitzig, as regards the action of the galvanic current, on the brain. Besides the objective phenomena referred to, there are certain subjective or mental states connected with them worthy of consideration. But these subjective phenomena (feeling of vertigo, etc.) are only accompaniments of the objective, and depend, not on the cerebellum, but on the cerebral hemispheres, just as reflex action may be accompanied by consciousness, though consciousness plays no part in the mechanism itself." This position we believe to be a correct one, and worthy of more extended consideration than we can give it here.

It will not be possible for us to quote and comment on all the passages of interest in Dr. Ferrier's highly suggestive chapter on the functions of the cerebellum, but we cannot pass them all by.

He says, that "the cerebellum would therefore seem to be a complex arrangement of individually differentiated centres, which in associated action regulate the various muscular adjustments necessary to maintain equilibrium of the body, each tendency to the displacement of the equilibrium round a horizontal, vertical or intermediate axis, acting as a stimulus to the special centre which calls into play the antagonistic or compensatory action."

This view would seem to be borne out by the facts of comparative anatomy, as well as by experiment. As regards the physiological relations of the cerebellar hemispheres to the cerebral, Dr. Ferrier has the following amongst other important remarks: He says "but while we may theoretically in all animals, and practically in many, abolish consciousness and volition by removal of the cerebral hemispheres, and still leave the mechanism of equilibration intact, yet in the normal state, cerebellar activity is associated with that of the hemispheres, and it is this association which serves to explain many of the facts which would seem to oppose the view which we have taken of the function of the cerebellum as a whole. * * * * *

The same muscular adjustments which are capable of being effected by the cerebellum, are also under the control of the will, and may be carried out by the cerebral hemispheres independently of the cerebellum. Hence it is that lesions of the cerebellum, while interfering with the mechanical adjustments against disturbances of bodily equilibrium, do not cause paralysis of voluntary motion of the muscles which are concerned in these actions. This is an exceedingly important fact which, though disputed by some, seems to be established experimentally beyond all question."

In speaking of the effects of lesions of the cerebellum, Dr. Ferrier makes a distinction as between reflex adjustment, and reflex action, as the latter phrase is ordinarily understood. He says, "in terming the effect of cerebellar lesion a *paralysis of reflex adjustment*, I do not thereby imply a *paralysis of reflex action*. This which would result from spinal lesion must necessarily coincide with paralysis of voluntary motion, as the path from the hemispheres would thereby be interrupted. What is implied is, that the same *combinations* of muscular action, which are co-ordinated in the cerebellum for the maintenance of the equilibrium, are capable of being called into *voluntary* action by the hemispheres. Hence, though lesions of the cerebellum destroy the *self-adjusting* co-ordination of muscular combinations necessary to maintain the equilibrium, they do not cause loss or paralysis of voluntary motion in the same muscles. So, conversely, by removal of the cerebral hemispheres, we cause paralysis of voluntary motion, but do not affect the independent mechanism of cerebellar co-ordination. When we make this distinction we are enabled to understand how limited lesions of the cerebellum may produce only

transient effects, and how even complete destruction of the cerebellum may ultimately be recovered from." In this way would Dr. Ferrier explain cases like that of Combette, or those of Weir Mitchell, who found pigeons to recover ultimately their power to maintain an equilibrium, after a time, notwithstanding the complete and permanent removal of the organ in question.

With most of the views which we have quoted, we can heartily agree. But inasmuch as they do not fully represent the case as it seems to us it should be, we will proceed to give an outline of our own opinions, as to the nature of the functions of the cerebellum.

We have been led to regard the cerebellum whatever its other functions may be,—as an important part of the nervous apparatus for the co-ordination of muscular motion, the highest part in fact, though in a peculiar sense. It forms no portion of the immediate apparatus proper, for this purpose, for this lies wholly in the cord, medulla, pons, and basal system of ganglia. But the cerebellum lies off to one side, and has as *its chief office the co-ordination of muscular motions, in subservency to the requirements of thought and emotion for the purposes of our higher or intellectual lives.* It uses the *immediate* nervous apparatuses for muscular co-ordination, so as *through them* to make muscular action subservient to the purposes of mind, more especially the expression in many ways of thought and feeling. Hence it is connected on the one hand with the cerebral hemispheres, and on the other by means of its middle and inferior peduncles, with the immediate co-ordinating apparatuses in the pons, medulla, and cord. Hence injury or even removal of the cerebellum does not finally destroy the power to co-ordinate, though lesions of the same, at least in the higher animals, always appear to disturb the maintenance of equilibrium. And hence, it comes to pass, as Dr. Ferrier says, that removal of the cerebral hemispheres in the lower animals does not always, or at times not at all, destroy the power to co-ordinate muscular action, for by such an operation the real apparatus for the co-ordination of muscular motion may remain intact.

It is the function of the cerebellum, we repeat, to secure those greatly complicated and delicate muscular co-ordinations and adjustments, required for the adequate expression by voice, hand, face, posture, etc., etc., of the innumerable thoughts, emotions, etc., which we make known by expressive signs to the outer world. This opinion requires that the cerebrum and cerebellum should have close anatomical relations. These, they have in point of fact, through the superior peduncles of the cerebellum. As will be seen in a later part of this notice, when speaking of the cerebrum and its functions, we hold to the localization of function in the same, in a certain sense. We may indeed anticipate so far as to say that it is our opinion,

that different parts of the cerebral cortex, are the seats, and in a sense, the organs of particular mental functions or faculties. These particular areas of the cortex—convolutions for example—are connected with particular and definite regions,—or convolution, if it pleases one to say so, of the cerebellum.

From the cortical seat of a particular thought or emotion, which gives rise to expressive acts, an impulse passes by way of the superior peduncle of the cerebellum to a particular part of the cortex of the opposite cerebellar hemisphere. This is excited in turn, and sends an impulse to one or more definite cell groups of the corpus dentatum, in the heart of each cerebellar hemisphere, and so, by way of the middle and inferior peduncles of the cerebellum, to the real immediate co-ordinating apparatus which is co-extensive with, and in close relations to, the central motor tract proper. In this view, the cerebellum, we repeat, does not form any part of the immediate co-ordinating apparatus, though it uses the latter for the purposes mentioned above.

There is a point in each cerebellar cortex, which corresponds to each particular locality of the cerebral cortex, so that they may be connected with each other for the purpose, that every thought or state of feeling, every volition which seeks expression, may find in the cerebellum a mechanism for the *involuntary* co-ordination of the muscular actions necessary to secure expression. But it may be possible to perform the same acts, or at least many of them, under conscious direction of the will, even in the absence of the cerebellum, just as in the case of breathing, which is ordinarily automatic, and unconsciously carried on, but which is often done by an effort of the will.

Such views as we have briefly described, in great measure, appear to coincide with those of Dr. Ferrier, as regards the cerebellum. They certainly seem to harmonize all known facts, as far as we know, better than any other hypothesis with which we are acquainted.

Dr. Ferrier rejects the opinion of Lussana (*Fisiologia dei centri Nervosi Encefalici, etc., etc.*—Vol. II., pp. 322-342—*Sistema pedunculare e cervello*, Padova, 1871), that the cerebellum is the seat of the muscular sense, and correctly, as we think. It is, therefore, in all probability, that part of the nervous apparatus which is chiefly concerned in *indirect, unconscious*, co-ordination, or delicate combination and adjustment, of muscular movements, which are especially subservient to the outward expression,—in the widest sense of the words—of thought and emotion.

Hence as already said it does not form a part of the *immediate* nervous coordinating apparatus, but in a somewhat circuitous manner, establishes a net-work of relations between the cerebrum and the co-ordinating apparatus proper, which lies below it. But we may find opportunity for further remarks on this subject,

when speaking of the functions and relations of the cerebrum, an account of which is crowded out of the present, but will be given in our October number.

(TO BE CONTINUED.)

VI.—SHORTER NOTICES.

- I. MYELITIS OF THE ANTERIOR HORNS, OR SPINAL PARALYSIS OF THE ADULT AND CHILD. By E. C. Seguin, M. D. New York: G. P. Putnam's Sons, 1877. 120 pp. Chicago: Jansen, McClurg & Co.
- II. A COURSE OF PRACTICAL HISTOLOGY; BEING AN INTRODUCTION TO THE USE OF THE MICROSCOPE. By Edward Albert Schaefer, Assistant-Professor of Physiology in University College, London. With Illustrations on Wood. Philadelphia: Henry C. Lea, 1877. Chicago: Jansen, McClurg & Co.
- III. TRANSACTIONS OF THE AMERICAN GYNECOLOGICAL SOCIETY. Vol. I. For the year 1876. Boston: H. O. Houghton & Co. 396 pages.
- IV. CONTRIBUTIONS TO REPARATIVE SURGERY. By Gurdon Buck, M. D. Illustrated by numerous engravings. New York: D. Appleton & Co., 1876. 237 pages.
- V. THE USE AND VALUE OF ARSENIC IN THE TREATMENT OF DISEASES OF THE SKIN. By L. Duncan Bulkley, A. M., M. D. New York: D. Appleton & Co., 1876. 45 pages.
- VI. TRANSACTIONS OF THE 79TH ANNUAL SESSION OF THE MEDICAL AND CHIRURGICAL FACULTY OF MARYLAND. Held at Baltimore, April, 1877. 190 pages.
- VII. THERAPEUTIC USE OF FARADAIC AND GALVANIC CURRENTS IN THE ELECTRO-THERMAL BATH, with History of Cases. By Justin Hayes, M. D. Chicago: Jansen, McClurg & Co., 1877. 112 pages.
- VIII. GENERAL INDEX TO THE NEW YORK MEDICAL JOURNAL. From April, 1865, to June, 1876 (twenty-three volumes). By James B. Hunter, M. D. New York: D. Appleton & Co., 1877. 144 pages. Chicago: Jansen, McClurg & Co.